

# AIRSPACE SYSTEMS PROGRAM

NEXTGEN

## NextGen Concepts and Technology Development Project

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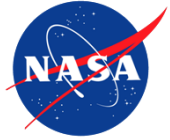
September 16-17, 2013



# Outline

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- Current Business Environment
- National Airspace Systems Overview
- Technical Challenge Overview and Specifics
- Summary



# Current Aviation Business Environment

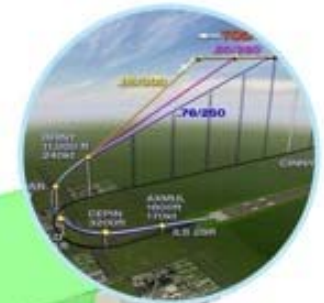
- Airline costs: Fuel - 25% and labor - 25%
- Fuel prices remain volatile
- Stiff competition in international market
- Financial survivability remains a challenge
- Horizontal and vertical integration trend continues (e.g., Delta purchasing refinery)
- Current focus of research and development – increasing efficiency
- Longer-term focus - reduce total cost, allow diverse use of airspace, increase mobility



# Gate-to-Gate Concepts and Technology



Flow and Airspace  
Planning



Arrival

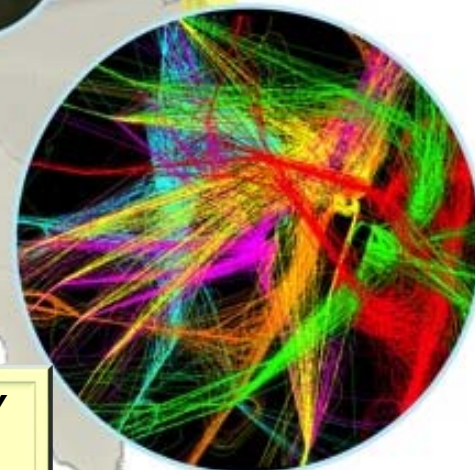
Surface  
Operation



En Route with  
Weather Avoidance



Departure



Dense  
Terminal

Surface  
Operation

**JOINT ECONOMIC COMMISSION (2007) FINDS DELAY  
BETWEEN 4.3 AND 5.3 MILLION HOURS  
COST OF DELAY \$41B  
ADDITIONAL 740M GALLONS OF FUEL**



# Technical Challenges



**Goal:** Enable NextGen and reduce the total cost of air transportation operations

**Thrust:** Aircraft and ground-based technologies to simultaneously increase throughput/capacity and aircraft efficiency

**Cross-Cutting Challenge:** All densities and all weather conditions

(1) ATM Technology Demonstration – 1: Improve arrival operations efficiency while increasing arrival throughput using integrated aircraft-based and ground-based automation technologies.

(2) Integrated Arrivals/Departures/Surface Operations: Simultaneously increase arrivals, departures, and surface operations efficiency while increasing overall throughput.

(3) Weather Integrated Decision-Making: Reduce weather-induced delays by integrating probabilistic and/or deterministic weather information with aircraft, flow and airspace management strategies.

(4) Separation Assurance Functional Allocation: Establish the basis for air/ground functional allocation for separation assurance including safe, graceful degradation of performance in response to off-nominal conditions.

(5) Oceanic Operations Efficiency Improvement: Increase oceanic airspace operational efficiency by efficient routing and rerouting based on changes in weather, and reduced separation minima based on ADS-B operations, and integrated air/ground procedures and technologies.

(6) Shadow Mode Assessment using Realistic Technologies for the NAS (SMART NAS): Develop a real/live, virtual, and constructive environment where alternative future concepts, technologies, air/ground human/machine architectures can be examined in an integrated fashion to assess NAS-level performance and benefits.

(7) Enabling Trajectory-based Operations: Increase efficiency of flights by enabling trajectory-based operations rather than airspace-based operations and reducing delay-increasing tactical changes to trajectories.

(8) Networked Air Traffic Management: Develop and demonstrate concepts, algorithms, technologies, architectures, and business models employing advanced networking capability that will significantly reduce duplication of data, processing, information, and allow for integrated decision making and the most cost-effective provision of air traffic management.

(9) AutoMax: Through the greatest use of autonomy, accommodate future demand, vehicle mix/airspace uses, and different operating business models to enable highest possible realization of economic value from the airspace operations at the lowest possible total cost of operations.

**Current Barriers:** Limitation of cognitive workload to develop optimal solutions on multiple dimensions (efficiency, throughput)

**NASA ASP Discriminator:** Develop air/ground concepts and technologies for developing precision schedule and delivery for gate-to-gate air traffic management operations for NextGen and beyond

**ASP Strategy:** Deliver/transfer products to enable changes in NAS – integrated and bite-sized



# TC 2: Integrated Arrival/Departure/Surface Operations

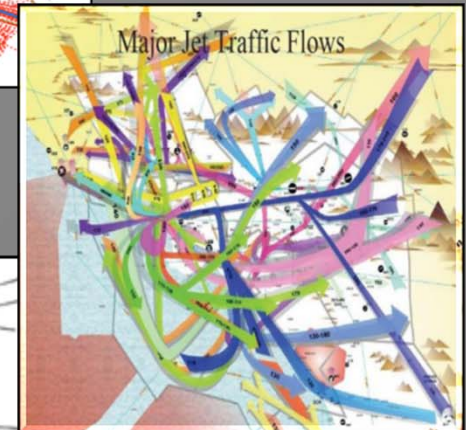
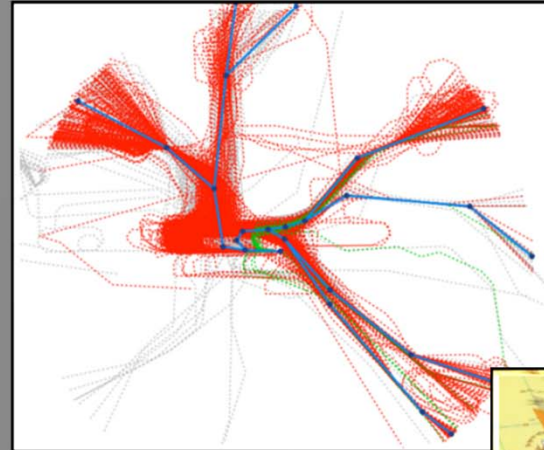


**Technology Challenge:** Simultaneously increase arrivals, departures, and surface operations efficiency while increasing overall throughput

**Need:** Efficient operations under low densities are possible, but simultaneously increasing throughput and operations efficiency for individual aircraft is challenging, due to cognitive workload limits

## NASA Technologies:

- Surface management automation
- Precision departure release planner
- Efficient descent approach
- Terminal scheduler
- Controller managed spacing
- Flight deck interval management



I saved 10 minutes at the hotel with speedy checkout  
10 minutes at the car rental with instant check in.  
Now I'm spending 6 hours on the runway."

Simultaneously increase throughput and individual aircraft efficiency

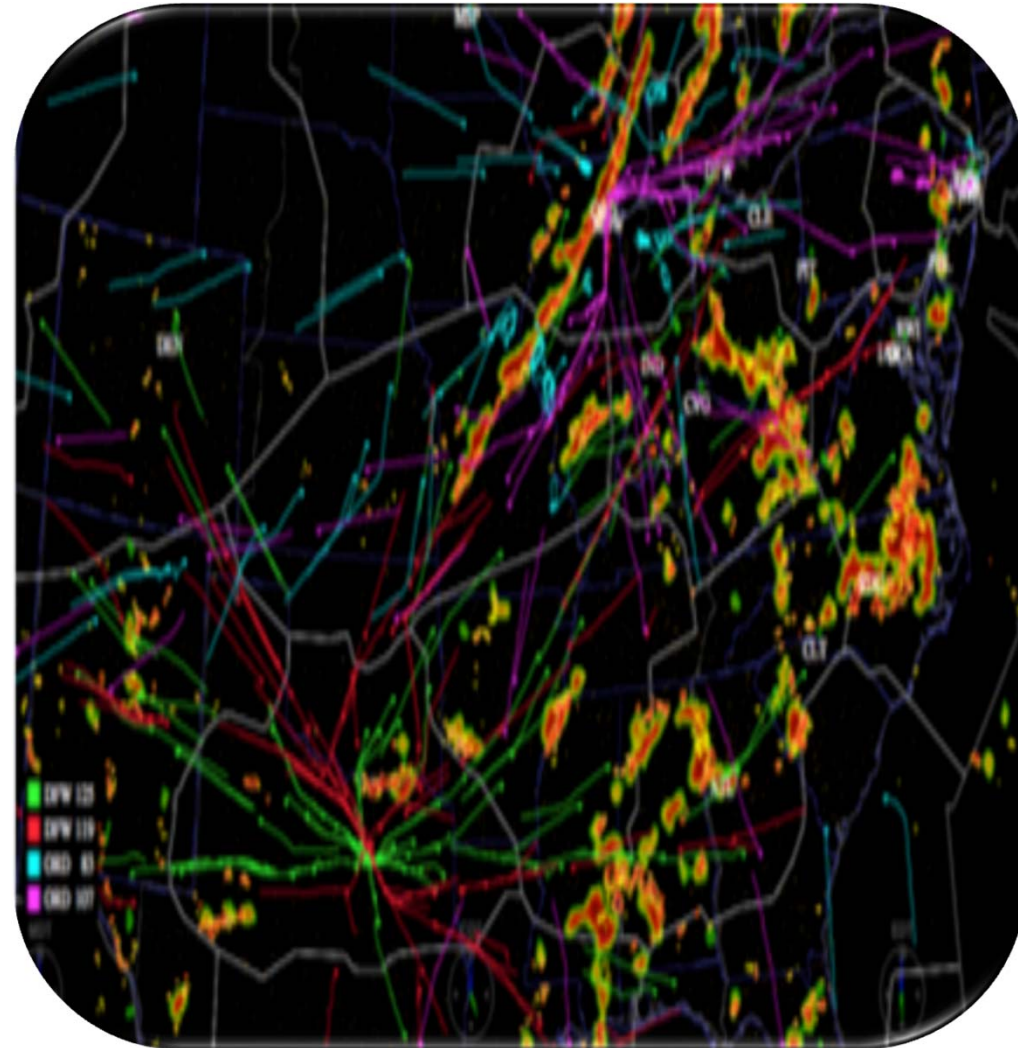
# TC 3: Weather Integrated Decision Making

**Technology Challenge:** Reduce weather-induced delays by integrating probabilistic and/or deterministic weather information with aircraft, flow and airspace management strategies

**Need:** ~25% aircraft get delayed and ~75% are due to weather. ~65% of delays are potentially avoidable

## NASA Technologies:

- San Francisco Stratus
- Dynamic Weather Routes (dispatcher)
- Traffic Aware Strategic Aircrew Request (Flight crew)
- Digital traffic management initiatives
- Learning automation for TFM



Weather contributes to 75% delays and costs \$10B

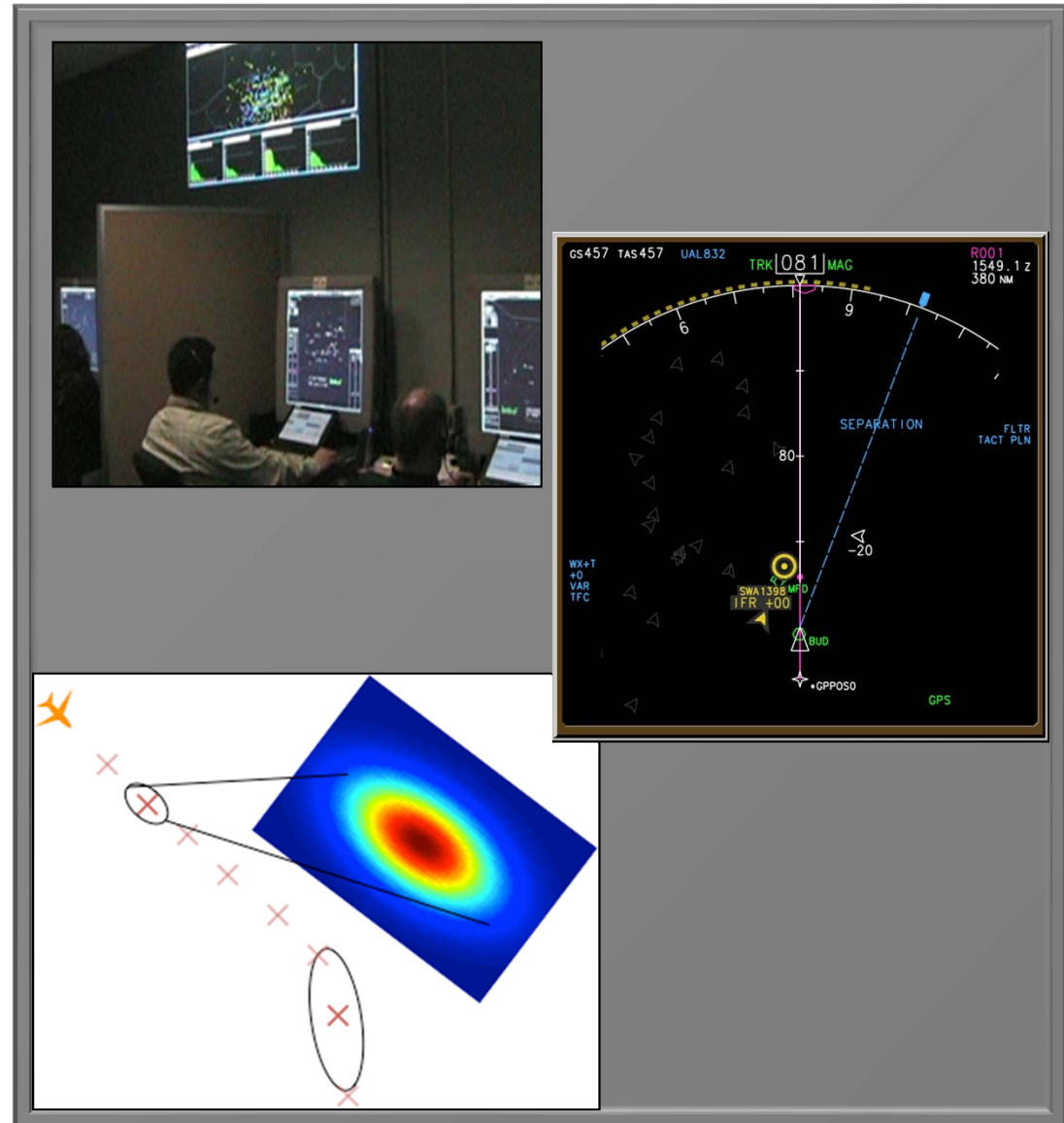
# TC 4: Separation Assurance Functional Allocation

**Technology Challenge:** Establish the basis for air/ground functional allocation for separation assurance including safe, graceful degradation of performance in response to off-nominal conditions.

**Need:** Need 100% detection and resolution

## NASA Technologies:

- Autonomous flight rules – Aircraft based separation assurance
- Ground-based separation assurance
- Functional allocation



Close to 100% detection and resolution performance is required



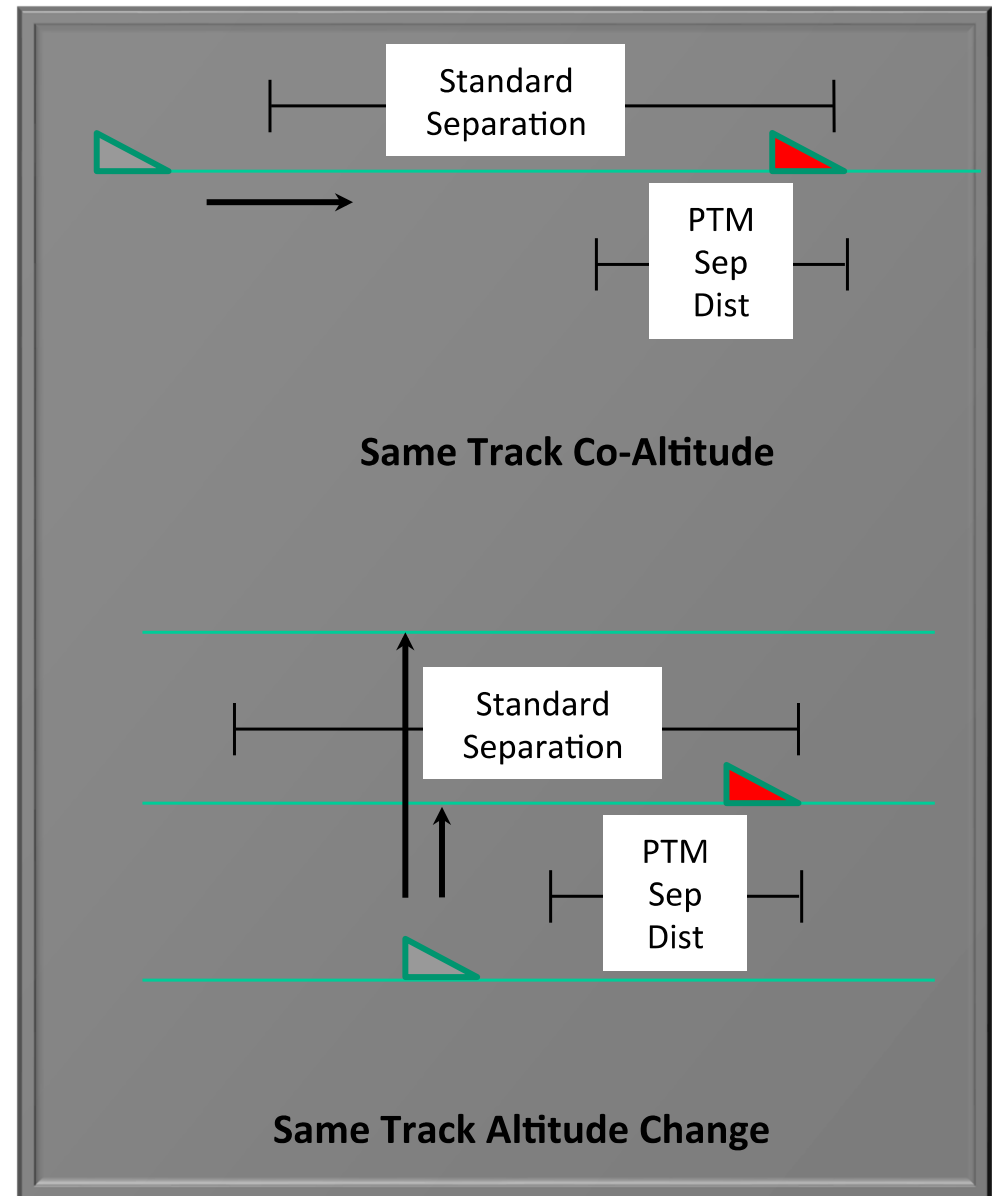
# TC 5: Oceanic Operations Efficiency Improvement

**Technology Challenge:** Increase oceanic airspace operational efficiency by efficient routing and rerouting based on changes in weather, and reduced separation minima based on ADS-B operations, and integrated air/ground procedures and technologies

**Need:** Tighter integration for TBO

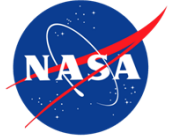
## NASA Technologies:

- Strategic flow management
- Dynamic weather routing
- Traffic Aware Strategic Aircrew Request
- ADS-B based aircraft separation (paired trajectory management)
- Tailored arrivals/departures



Number of technologies to promote TBO in oceanic airspace

# TC 6: Shadow Mode Assessment Using Realistic Technologies for the NAS (SMART NAS)



## TC7: Enabling Trajectory-based Operations

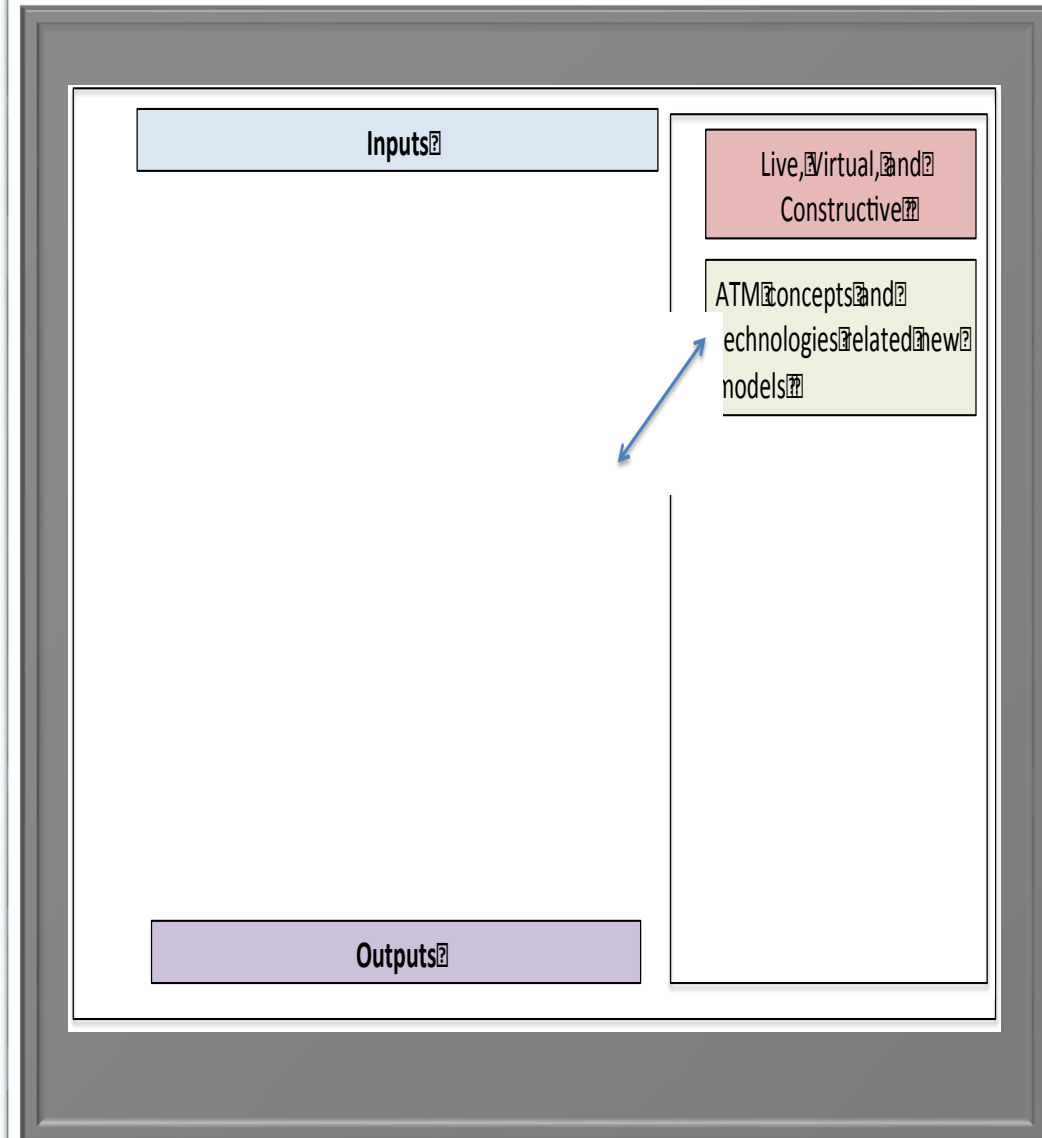
### Technology Challenge:

- Develop a real/live, virtual, and constructive environment where alternative future concepts, technologies, air/ground human/machine architectures can be examined in an integrated fashion to assess NAS-level performance and benefits
- Increase efficiency of flights by enabling trajectory-based operations rather than airspace-based operations and reducing delay-increasing tactical changes to trajectories

**Need:** Capability to conduct integrated evaluations, using plug-and-play, real data/constraints, live/virtual/constructive architecture

### NASA Technologies:

- SMART NAS
- Technologies for Oceanic Operations
- TBO storyboard, gaps, analysis, and end-to-end technology integration



# TC 8: Networked ATM

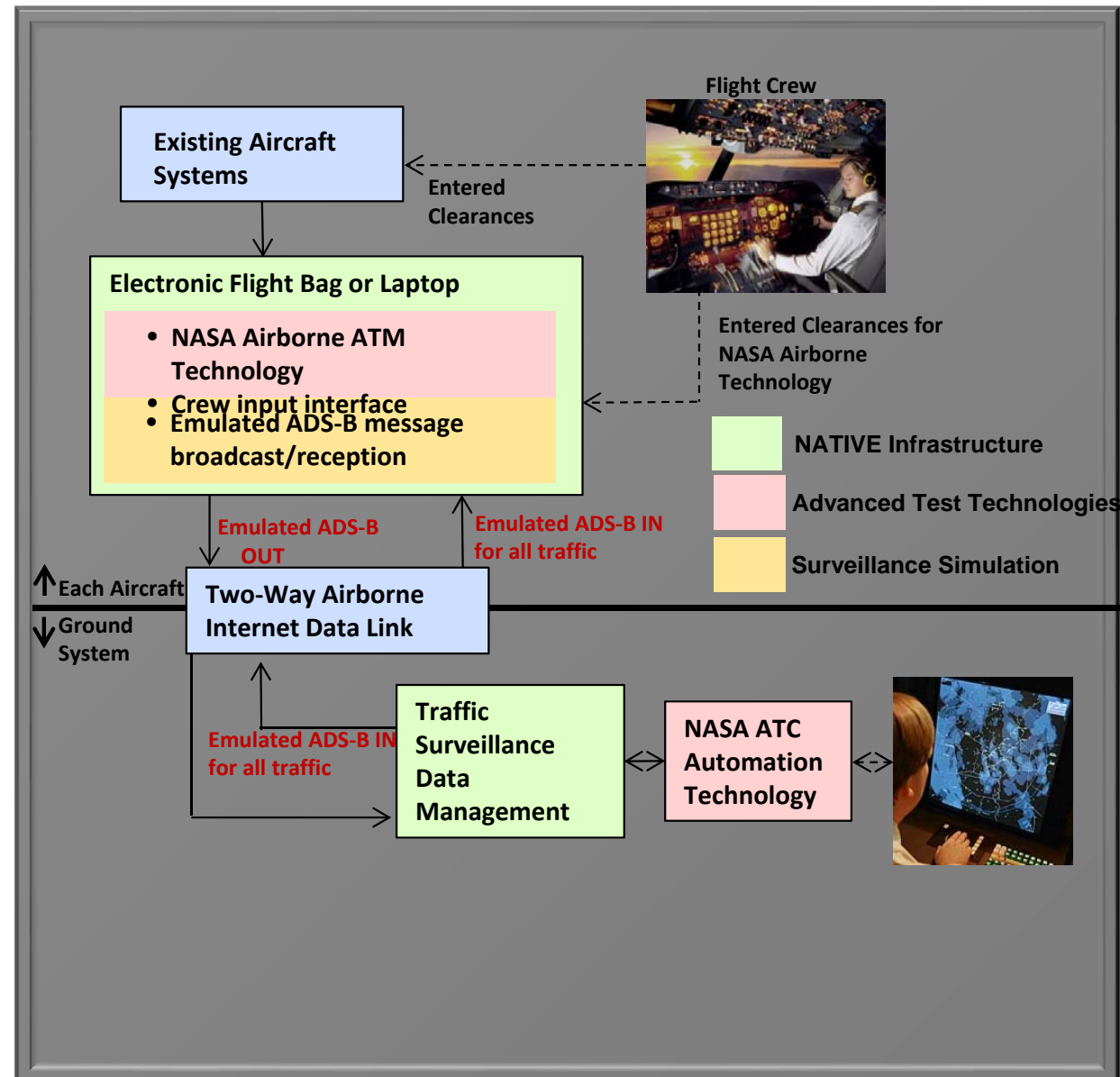


**Technology Challenge:** Develop and demonstrate concepts, algorithms, technologies, architectures, and business models employing advanced networking capability that will significantly reduce duplication of data, processing, information, and allow for integrated decision making and the most cost-effective provision of air traffic management.

**Need:** Avoid duplication, reduce certification costs, increase productivity, allow third-party applications

## NASA Technologies (under planning)

- Chicago snow problem
- Push back time uncertainty
- Trajectory management
- More being identified





# TC 9: AutoMax



**Technology Challenge:** Through the greatest use of autonomy, accommodate future demand, vehicle mix/airspace uses, and different operating business models to enable highest possible realization of economic value from the airspace operations at the lowest possible total cost of operations.

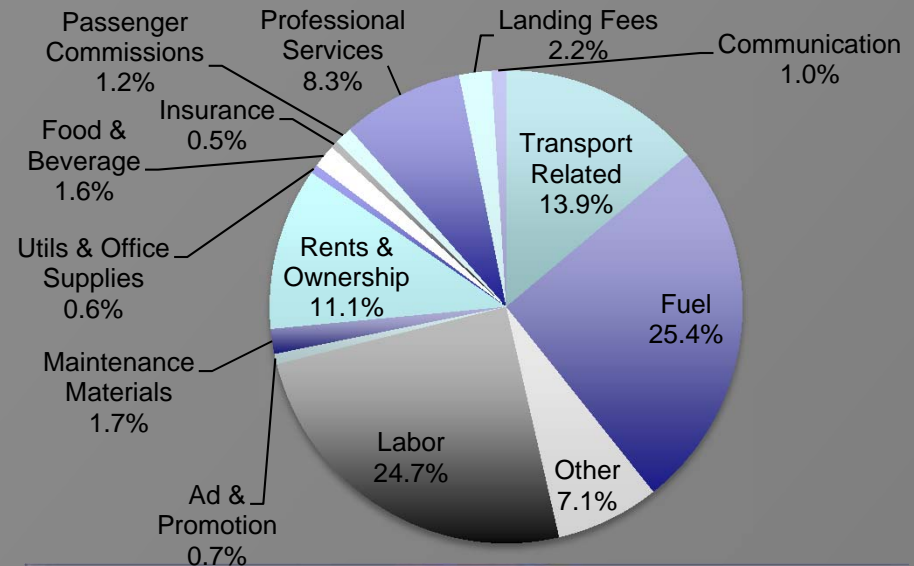
**Need:** Increase service provider and user productivity

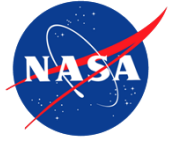
- 25% fuel and 25% labor cost
- About \$6B to operate NAS

## NASA Technologies (under planning)

- Entire airspace operations
- Research plan in progress
  - Overall design
  - Technology infusion roadmap (e.g., Single Pilot Operations)

### Operating Costs by Objective Grouping

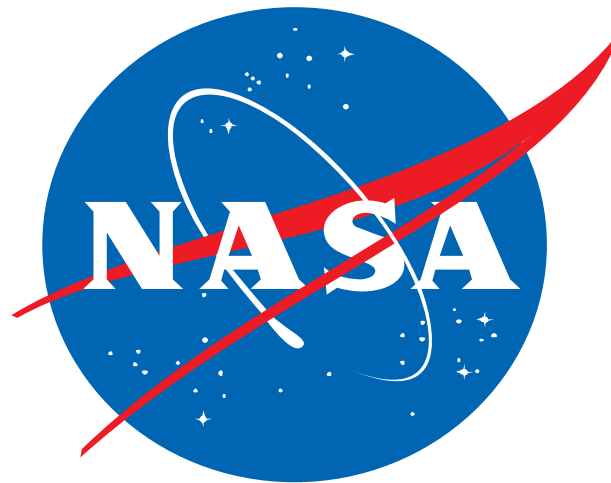
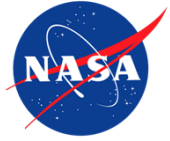




## Summary

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- Current products – En Route Descent Advisor, ATD-1, Precision Departure Release Capability, Dynamic Weather Routing are making impact
- ATM R&D beyond NextGen continues to be an urgent national need for economic growth and viable aviation
- Opportunities for collaboration - AutoMax, SMART NAS, and UTM



*Innovate Relentlessly*



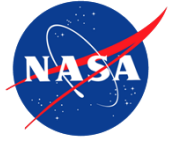
# Shadow Mode Assessment using Realistic Technologies for NAS (SMART NAS)

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- **Motivation**

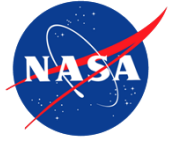
- General agreement that National Airspace Systems needs to transform and pace of transformation is rather slow
- NAS is a complex system with many sub-components with high safety requirements
  - Results in incremental and evolutionary changes that are validated
- Such incremental upgrade approach is rather slow and does not consider integrated operations efficiently – could take many decades to get to “true” next generation



# Objective

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- Develop quicker approach to validate next generation concepts, technologies and their integration to enable transformation of the NAS
- Reduce the time to validate concepts, technologies and their interactions and integration
- Provide plug-and-play capability to compare alternative approaches
- Provide real-time assessment of technologies as compared with current operations



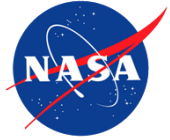
# Approach

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- Develop a shadow-mode capability that will run the NAS operations in parallel, 24-7 and real-time, with actual data inputs as the NAS but using advanced concepts, technologies, and procedures
- Offer plug-and-play capability to examine alternating concepts and technologies
- Examine robustness, reliability, stability of concepts, algorithms, and technologies as compared with NAS
- Allow real-time (but model driven) or human-in-the-loop involvement for selected parts



# Automation Maximus (AutoMax)



- Goal: Identify and develop the maximum possible justifiable use of automation to address the needs of future air transportation and airspace operations (2035+).
- Background
  - Service provider and user costs are very high
  - Future airspace uses are diverse (hyper/super sonic, commercial space launches, airships, flying wind turbines, UAVs, fixed and rotary wing)
  - Need to accommodate mixed equipage and diverse business models (p2p, hub-and-spoke, on-demand, air taxi, personal vehicles, etc)
  - Increased mobility, scalability, predictability needed at affordable costs
- Parallels from Space and Exploration
  - Needs for automation, autonomy, autonomous operations, autonomicity stem from long lags in communications (e.g, Mars), rapid decision (e.g., launch abort), scalability (e.g., multiple successive launches simultaneously), etc.
  - Opportunistic implementation of automation, rather than a big whole-sale change
- Challenges
  - Technology development for larger-scale air traffic management
  - V&V of autonomous systems and technology providing autonomicity
  - Role of humans (adaptive automation, how much)
  - Harmonized transition from current NAS to AutoMax future
- Potential partnerships: Industry, Academia, other Government organizations

- Approach
  - Identify future trends, demand profiles, different uses of airspace, and technology paths
  - Create a roadmap that will enable technology and roles/responsibilities change from current operations to future
  - Develop concepts and technologies – conduct research needed to support the technology development
  - Use SMART NAS to examine alternative automation architectures
  - Examples for AutoMax products: TCAS replacement, Strategic Flow Management, Strategic Weather integration, Flight Dispatching, Oceanic Operations, Integrated Arrival/Departure/Surface Operations, Single Pilot Operations/Remote Pilot Operations for commercial carriers, and Trajectory based operation, Vehicle autonomy for different classes of vehicles, and maximum automation for the entire ATM
  - Autonomicity for ATM system: Self-configuration (e.g. Microsoft windows Normal mode to safe mode), Self-optimization (capacity focused), Self-protection (detection anomalies and degraded signals), and Self-healing (recovery)
  - Develop requirements for sensors, redundancies, communications, technologies for ATM functions – Define architecture for AutoMax that is supported by benefits and costs
- Inter-mega cities and intra mega cities – Covers all kinds of airspace uses
- Progress
  - First Workshop: ATM experts to understand the needs and future trends
  - Second Workshop: Autonomy experts from ARC, DFRC, JPL, JSC, LaRC, KSC, and MSFC
  - Research planning: A team is formed and by December 2013 first research plan is expected to be completed

# Unmanned Aerial System Traffic Management (UTM)



**Goal:** Enable significant UAS traffic at low altitudes for goods and services delivery

## Background

- History of Air Traffic Management: 1956 crash over Grand Canyon
- Several efforts of integrating civilian UAS into National Airspace System underway
- None of them are addressing civilian low altitude applications for goods and services delivery

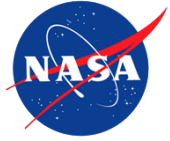
## Main functions

- Congestion management, conflict and collision detection/prediction and avoidance, obstacle avoidance, wind/weather/wake detection/prediction, noise, mix of traffic helicopter, model a/c, and eventually personal aircraft

## Next Steps (NASA seedling proposal)

- First step is to develop initial concept design, functional requirements, and systems requirements to enable significant low altitude operations
- Airspace design, communication/navigation/surveillance, and infrastructure requirements





# Cloud based applications

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- Cloud based trajectory management
  - Aircraft based and ground based trajectories, no one system has complete information
- Cloud based aircraft operations
  - Cost, certification and competition pressures
  - Need a different architecture
- Cloud based fleet management
  - Most aircraft now have internet, interconnected system would allow to manage the fleet and all assets based on changing conditions and priorities for flights